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BEARING TESTS OF MAGNESIUM-ALLOY SHEET

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SUMMARY

Bearing tests of AM-3S, AM-52S, and AM-C57S magnesium-alloy sheet in various thicknesses and tempers were made. Bearing yield and ultimate strengths were determined and compared for various edge distances and for various ratios of loading-pin diameter to sheet thickness. Tensile strengths were determined and ratios of average bearing yield and ultimate strength to tensile strength are given.

The results of the tests indicated that ultimate bearing strengths increased with edge distances up to 1.5 to 2 times the diameter of the loading pin; that ultimate bearing strengths are a function of ratio of pin diameter to sheet thickness; that bearing yield strengths generally are not sensitive to ratios of pin diameter to sheet thickness; and that these properties are effected only slightly by increases in edge distance greater than 1.5 diameters.

INTRODUCTION

The increasing use of magnesium alloys in aircraft construction has emphasized the need for more complete information regarding the mechanical properties of these materials. The object of this investigation was to determine the bearing yield and ultimate strengths of several of the more common magnesium alloys and to establish, as far as possible, ratios of bearing values to tensile strengths which may be used as a basis for design. This report includes, in addition to data on bearing strengths, the tensile properties of the alloys investigated and some data on compressive and shear strengths.

MATERIAL

(See appendix A, p. 13)

Tests were made of three magnesium alloys in the form of sheet - AM-3S, AM-52S, and AM-C57S. All alloys were furnished in -O and -H tempers in a nominal thickness of 0.064 inch, and in -R tempers (between -O and -H) in thicknesses of 0.125 inch and 0.250 inch.

Table I gives the mechanical properties of the materials used. (See references 1 and 2.) Although not included here, stress-strain data were obtained in tension for all the 0.064-inch sheet and in compression for all three thicknesses of sheet used. These measurements indicated an initial linear stress-strain relationship in all cases. Under some conditions of cold work on magnesium alloys, this type of stress-strain relation is not obtained. (See reference 3.)

It will be noted in table I that the tensile strengths and elongations obtained normal to the direction of rolling were slightly higher in most cases than those parallel to the direction of rolling - a condition contrary to that generally found in aluminum-alloy sheet. The compressive yield strengths were all below the corresponding tensile yield strengths, the differences in some cases being as much as 40 percent. The shear strengths obtained by punching tests averaged slightly over 50 percent of the tensile strengths.

The tensile properties of the -O and -H tempers given in table I compare quite favorably with the typical values given in table 3 of reference 4. There are no typical properties published for the -R temper, but it is stated on page 16 of reference 4 that the properties of this temper are between those of the -O and -H tempers. This was found to be substantially true in the case of the properties parallel to the direction of rolling, but a number of exceptions were found in the case of the properties in the opposite direction. The tensile yield and ultimate strengths of the 0.125-inch and 0.250-inch AM-3S sheet in the -R temper, normal to the direction of rolling, were higher than those found for the 0.064-inch sheet of this alloy in the -H temper. The corresponding properties of the 0.250-inch AM-52S sheet in the -R temper, on the other hand, were slightly less than those found for the 0.064-inch sheet of this alloy in the -O temper. It appears from these comparisons that the materials supplied in the -R temper were not all representative of commercial sheet.

TEST PROCEDURE

The bearing tests were made, as shown in figure 1, with the 40,000-pound capacity Amsler testing machine. One series of specimens was composed of strips $2\frac{1}{4}$ inches wide loaded through a steel pin 1/2 inch in diameter, and the other was composed of strips 2 inches wide loaded through a steel pin 1/4 inch in diameter. All specimens were originally about 30 inches long, cut parallel to the direction of rolling. Duplicate specimens were provided for all tests with the 1/2-inch pin, except in the case of the 0.250-inch sheet in which three specimens were used; while triplicate specimens were provided in most cases for the tests with the 1/4-inch pin. Edge distances – that is, the distances from the center of the hole to the edge of the test strip in the direction of loading – were varied on each specimen; distances of 1, 1.5, 2, 3, and 4 times the pin diameter D were used in the tests with the 1/2-inch pin and distances of 1.5, 2, and 4 times the pin diameter were used with the 1/4-inch pin. The holes in the specimens were drilled and reamed to provide a close fit on the pins. A complete set of edge distances, covering the entire range investigated, was obtained on each specimen by shearing or sawing off the damaged end after one test (about 3/4 in. below the center of the old hole) and redrilling at a new edge distance for the next test. Auxiliary tests, in which the procedure was repeated several times with the same edge distance, indicated that the small amount of tensile strain produced in the portion of the specimens below the pin in the first loading had no significant effect upon the results of subsequent tests. In most of the cases involving determinations of bearing yield strength, the average tensile stresses developed range from about 6000 to 10,000 pounds per square inch, or only one-eighth the corresponding ultimate bearing strengths.

The data on bearing stress and hole deformation, from which yield-strength values were determined, were obtained by measuring the relative movement of the pin and the sheet on the under side of the pin by means of a filar micrometer microscope reading directly to 0.01 millimeter and by estimation to 0.002 millimeter. The under side of the pin projecting from the sheet on the microscope side was flattened slightly to provide a shoulder in the plane of the sheet on which one of the reference points for the microscope readings could be located. The edge of the hole provided the reference point on the sheet. Figure 1 shows the setup used. Hole-deformation measurements were made on all the specimens tested with the 1/4-inch pin and on one of the three 0.250-inch specimens tested with the 1/2-inch pin. In all other tests, values of only ultimate bearing strength were obtained.

RESULTS AND DISCUSSION

Tables II and III summarize the bearing yield and ultimate strengths obtained. The values of bearing yield strength given were selected from the hole-deformation curves in figures 2 to 13 as the stresses corresponding to an offset of 2 percent of the hole diameter from the initial straight-line portion of the curves. It should be emphasized that no definite criterion has ever been established for selecting bearing yield strengths and that the 2 percent offset method used herein is quite arbitrary.

Although the data given in table II for the tests with the 1/2-inch pin indicate some small inconsistencies regarding the influence of edge distance upon ultimate bearing strengths, it appears that for the proportions investigated there was no particular advantage in using edge distances greater than twice the diameter of the pin. In fact, for a number of the tests of the 0.064-inch sheet, there was no significant increase in ultimate bearing strength for edge distances greater than 1.5 diameters. The behavior in the case of the 0.064-inch material, in which failure involved to some extent the buckling resistance of the sheet above the pin, was typical of that found in aluminum when comparable ratios of pin diameter to sheet thickness are used. The fact that the 0.125-inch and 0.250-inch sheet tested with the 1/2-inch pin did not show an appreciable gain in ultimate strength for edge distances greater than twice the pin diameter, as generally found in aluminum, may apparently be attributed to the distinctly different type of action obtained. Bearing failures in these tests were characterized by a crumbling or shearing of the material above the pin rather than by an upsetting action which, of course, results in increased effective bearing areas and high values of ultimate bearing strength.

The results of the tests with the 1/4-inch pin given in table III likewise show no appreciable gain in ultimate bearing strength for edge distances greater than twice the pin diameter. The important comparison to be made between these data and those given in table II concerns the effect of pin diameter upon ultimate bearing strengths. For an edge distance of 2 diameters in the 0.064-inch sheet, the strengths obtained with the 1/4-inch pin ranged from approximately 8000 to 16,000 pounds per square inch higher than those obtained with the 1/2-inch pin. The differences between the strengths obtained with the two sizes of pin in the 0.125-inch sheet were not so marked, although the values for the 1/4-inch pin were, with one exception, higher. The 1/2-inch pin was the only size used in the 0.250-inch sheet; but the ultimate strengths obtained in these tests were in fair agreement with those obtained with the 1/4-inch pin in the 0.125-inch sheet, for which the ratio of pin diameter to thickness was the same. The agreement between the latter test results also indicates that the ratio of specimen width to pin diameter, which was 8 in the case of the 1/4-inch pin and 4.5 in the case of the 1/2-inch pin, was apparently not a significant factor in these tests.

Figures 14 to 16 show typical bearing failures obtained for different edge distances in the tests with the 1/2-inch pin. In general, the failures shown indicate a more brittle action than is commonly found in similar tests of aluminum-alloy sheet. The relatively low elongation values given in table I for the -H and -R tempers are consistent with this difference in behavior.

The bearing yield strengths given in table III, which correspond to the stresses producing a permanent set of 2 percent in the original diameter of the hole, show considerably less change with increases in edge distance beyond 1.5 pin diameters than do the ultimate bearing strengths. This behavior is typical of that found in the aluminum alloys and is understandable since first yielding in bearing appears to be a local phenomenon and, as such, should be relatively independent of edge distances and other specimen proportions. For this reason it is assumed that the yield-strength values, which were determined for the most part from the tests of the 1/4-inch pin, are representative for the materials used. In the tests of the materials in the -R tempers, which provide the only cases in which comparisons may be made, the yield strengths obtained for 0.125-inch material tested with the 1/4-inch pin averaged about 8 percent higher than those found for the 0.250-inch material tested with the 1/2-inch pin. Part of this difference, however, may be attributed to a difference in the strengths of the two thicknesses of sheet as shown in table I.

Although the results given in tables II and III show definitely the effect of certain specimen proportions upon bearing yield and ultimate strengths, significant differences between the bearing characteristics of different alloys and tempers of sheet are not so evident. Table IV gives average ratios of bearing yield and ultimate strength to tensile strength in an effort to eliminate as far as possible the effect of differences and irregularities in the properties of the material tested and to reduce all data to a common basis for comparison. Aside from the effects of specimen proportions already considered, however, these ratios do not appear to indicate any consistent relationships between the bearing properties of different alloys or tempers. Small differences may undoubtedly be attributed to variations which are recognized as inherent in the bearing test. Until more data are available, therefore, it is believed that the ratios in table IV should be subjected to a very general and conservative interpretation.

Table V summarizes the ratios of bearing yield and ultimate strength to tensile strength selected from these tests as a basis for predicting nominal bearing values for other lots of these same amgnesium alloys. Typical bearing values, or representative minimum values such as are used in aircraft design presumably may be obtained by multiplying the ratios in table V by typical or minimum values of tensile strength.

CONCLUSIONS

The results of these tests of AM-3S, AM-52S, and AM-C57S magnesium-alloy sheet in various thicknesses and tempers justify the following general conclusions regarding bearing strengths:

1. The tensile properties of the 0.064-inch sheet investigated in the -O and -H tempers compare quite favorably with the typical values given for these materials in reference 4. The bearing values obtained for this material, therefore, are believed to be representative for commercial sheet of the kind used.

2. The tensile properties of the 0.125-inch and 0.250-inch sheet in the "as-hot-rolled" or -R temper were not in all cases between those for the -O and -H tempers, as is generally assumed. Although this irregularity probably had little effect upon bearing-strength characteristics, additional tests of more normal "-R" material may be desirable.

3. Ultimate bearing strengths increased with edge distance for values of edge distance up to 1.5 to 2 times the diameter of the pin. For greater edge distances there was no appreciable gain in strength in most cases.

4. Ultimate bearing strengths are a function of ratios of pin diameter to sheet thickness as well as edge distance. Strengths obtained in the tests of the 0.064-inch sheet with 1/4-inch-diameter pin (ratio of pin diameter to sheet thickness = 4) at an edge distance of 2 diameters were from 8000 to 16,000 pounds per square inch higher than found using a 1/2 inch-diameter pin (ratio of pin diam. to sheet thickness = 8) at the same edge distance. The effect of ratios of pin diameter to sheet thickness was not so pronounced for ratios of 4 or less.

5. For specimens having a ratio of pin diameter to sheet thickness of 8, bearing failures for edge distances of 1.5 diameters or greater were accompanied by local buckling of the sheet above the pin - a type of action similar to that found in tests of aluminum. For ratios of pin diameter to sheet thickness of 4 or less, however, failures for edge distances of 2 diameters or greater were characterized by a shearing or crumbling of the material above the pin rather than by an upsetting action, as generally found in aluminum.

6. Bearing yield strengths, selected as the stresses corresponding to an arbitrarily selected permanent set of 2 percent in the original hole diameter, increased only slightly for edge distances greater than 1.5 times the diameter of the pin. Although most of the determinations of bearing yield strength were made from tests with a 1/4-inch-diameter pin, it seems reasonable to assume that this property of the material is not sensitive to ratios of pin diameter to sheet thickness.

7. Ratios of average bearing yield and ultimate strength to tensile strength for all tests are summarized in table IV. The ratios selected arbitrarily from this

table as providing an approximate but conservative basis for predicting nominal bearing values for other lots of these same materials are given in table V.

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3. Templin, R. L., and Sturm, R. G.: Some Stress-Strain Studies of Metals. Jour. Aero. Sci., vol. 7, no. 5, March 1940, pp. 189-198.

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TABLE I.- MECHANICAL PROPERTIES OF MAGNESIUM-ALLOY SHEET[a]

[Shear strengths obtained by punching test; diam. of punch, 2.735 in.; diam. of blank, 2.750 in.]

Alloy and temper	Nominal thickness (in.)	Normal to direction of rolling: Tensile strength (lb/sq in.)	Normal: Tensile yield strength (offset = 0.2 percent) (lb/sq in.)	Normal: Elongation in 2 in. (percent)	Normal: Compressive yield strength[b] (offset=0.2 percent) (lb/sq in.)	Parallel to direction of rolling: Tensile strength (lb/sq in.)	Parallel: Tensile yield strength (offset=0.2 percent) (lb/sq in.)	Parallel: Elongation in 2 in. (percent)	Parallel: Compressive yield strength[b] (offset=0.2 percent) (lb/sq in.)	Parallel: Shear strength (lb/sq in.)
AM-3S-O	0.064	32,000	15,800	20.5	14,600	33,100	18,100	18.5	—	—
		31,000	15,800	18.5	—	32,600	18,300	18.5	—	[c]18,800
						[c]32,400	[c]19,100	20.0	—	
	Average	31,500	15,800	19.5	14,600	32,700	18,500	19.0	—	18,800
AM-52S-O	0.064	38,800	25,800	22.0	—	37,600	23,000	22.0	—	—
		38,900	25,900	17.0	—	37,600	22,900	[d]19.0	—	[c]21,100
					—	[c]36,800	[c]20,800	20.8	—	
	Average	38,850	25,850	19.5	—	37,330	22,200	21.4	—	21,100
AM-C57S-O	0.064	41,000	28,500	[d]10.5	16,800	40,300	22,700	[d]11.0	—	—
		42,200	28,600	16.0	—	41,400	23,000	17.5	—	[c]20,200
						[c]41,200	[c]22,000	19.5	—	
	Average	41,600	28,550	16.0	16,800	40,970	22,570	18.5	—	20,200
AM-3S-H	0.064	34,900	25,900	14.5	21,000	37,000	32,400	6.0	23,000	—
		34,700	25,600	12.5	—	36,000	31,900	5.0	—	[c]19,000
						[c]37,600	[c]33,400	3.0		
	Average	34,800	25,750	13.5	21,000	36,870	32,570	4.7	23,000	19,000
AM-52S-H	0.064	50,600	40,000	8.5	36,000	45,600	38,100	4.0	30,600	—
		51,200	40,400	9.5	—	45,900	37,800	4.5	—	[c]22,800
						[c]47,300	[c]38,600	3.3		
	Average	50,900	40,200	9.0	36,000	46,270	38,170	3.9	30,600	22,800
AM-C57S-H	0.064	48,000	36,800	7.0	31,000	44,600	35,200	6.0	26,400	—
		53,100	40,400	8.5	—	45,500	38,600	2.0	—	[c]22,700
						[c]46,300	[c]38,200	2.0		
	Average	50,550	38,600	7.8	31,000	45,500	37,300	3.3	26,400	22,700
AM-3S-R	0.125	39,500	28,100	8.5	27,800	38,100	28,300	6.0	22,800	—
AM-52S-R	.125	39,500	27,600	16.0	17,600	39,500	27,600	15.0	17,600	—
						[c]39,500	[c]26,000	15.3		—
	Average	39,500	27,600	16.0	17,600	39,500	26,800	15.2	17,600	—
AM-C57S-R	0.125	42,400	27,100	14.0	18,300	41,700	26,200	13.0	18,000	—
AM-3S-R	0.250	38,300	27,600	11.5	—	35,600	28,500	8.0	22,800	—
AM-52S-R	.250	38,700	25,100	16.0	16,200	39,200	27,900	14.5	16,200	—
AM-C57S-R	.250	41,800	26,600	12.5	16,400	41,500	26,000	11.0	16,800	—

[a]Standard tension test specimens for sheet metals - see fig. 2 of reference 1. Single-thickness compression specimens - see reference 2.
[b]When values of compressive yield strength are missing failure occurred before the required strain was obtained.
[c]Average for two tests. All other results for single tests.
[d]Broke through defect. Values of elongation omitted from average.

TABLE II.- BEARING STRENGTHS OF MAGNESIUM-ALLOY SHEET

[All values are averages of two tests parallel to direction of rolling. Specimens $2\frac{1}{4}$ in. wide, loaded through steel pin 1/2 in. in diam.]

Alloy and temper	Nominal thickness (in.)	Ultimate bearing strengths for different edge distances in terms of pin diameter D (lb/sq in.)				
		1D	1.5D	2D	3D	4D
AM-3S-O	0.064	30,000	40,700	45,300	42,000	44,000
AM-52S-O	.064	34,900	50,800	54,000	54,100	53,600
AM-C57S-O	.064	35,900	54,800	52,000	56,500	54,200
AM-3S-H	0.064	33,800	50,400	51,400	57,600	49,600
AM-52S-H	.064	43,100	62,900	63,900	60,900	60,400
AM-C57S-H	.064	41,100	63,600	64,300	62,300	62,400
AM-3S-R	0.125	35,900	55,900	64,900	59,600	58,700
AM-52S-R	.125	34,600	53,800	64,200	65,400	64,600
AM-C57S-R	.125	35,500	54,800	66,000	69,700	68,300
AM-3S-R	0.250	35,800	56,100	64,200	63,500	64,100
AM-52S-R	.250	34,200	53,000	64,600	69,400	66,000
AM-C57S-R	.250	33,800	54,100	62,800	64,700	70,600

TABLE V.- TENTATIVE RATIOS OF BEARING ULTIMATE AND YIELD STRENGTH TO TENSILE STRENGTH SELECTED FROM TABLE IV AS A BASIS FOR PREDICTING NOMINAL BEARING VALUES FOR AM-3S, AM-52S, AND AM-C57S MAGNESIUM-ALLOY SHEET

Temper	Bearing yield strength / Tensile strength	Bearing ultimate strength/Tensile strength		
		$\frac{\text{Pin diam.}}{\text{Sheet thickness}} = 8$	$\frac{\text{Pin diam.}}{\text{Sheet thickness}} = 4$ or less	
			Edge distance = 1.5D	Edge distance = 2D or more
-O	0.9	1.3	1.4	1.6
-R	1.0	1.3	1.4	1.6
-H	1.1	1.3	1.5	1.6

TABLE III.- BEARING STRENGTHS OF MAGNESIUM-ALLOY SHEET

[Specimens of 0.064 and 0.125-in. sheet were 2 in. wide, loaded through steel pin 1/4 in. in diameter. Specimens of 0.250-in. sheet were 2¼ in. wide, loaded through steel pin 1/2 in. in diameter. All tests were parallel to the direction of rolling.]

Alloy and temper	Nominal thickness (in.)	Specimen	Bearing strengths (lb/sq in.)					
			Edge distance=1.5D		Edge distance=2D		Edge distance=4D	
			Ultimate	Yield[a]	Ultimate	Yield[a]	Ultimate	Yield[a]
AM-3S-O	0.064	1	45,800	25,200	50,900	27,400	56,000	32,800
		2	45,800	26,400	54,900	27,600	56,800	31,200
		3	44,100	27,200	54,600	29,000	56,000	28,400
		Average	45,200	26,300	53,500	28,000	56,300	30,800
AM-52S-O	.064	1	55,000	33,600	66,900	36,000	67,700	41,600
		2	54,900	33,400	66,600	35,200	67,500	40,000
		3	55,800	34,200	66,300	35,600	70,000	40,400
		Average	55,200	33,700	66,600	35,600	68,400	40,700
AM-C57S-O	.064	1	54,200	36,600	67,500	36,400	66,800	43,200
		2	54,600	39,600	67,500	39,600	69,000	44,000
		3	54,900	39,000	68,700	37,600	69,200	43,600
		Average	54,600	38,400	67,900	37,900	68,300	43,600
AM-3S-H	0.064	1	55,600	40,400	59,600	38,800	59,900	40,300
		2	55,600	38,800	59,800	38,500	60,000	41,000
		3	55,800	38,000	59,700	41,000	60,000	40,800
		Average	55,700	39,100	59,700	39,400	60,000	40,700
AM-52S-H	.064	1	72,600	54,400	76,200	57,900	77,300	59,800
		2	71,600	55,200	76,600	59,600	78,500	58,400
		3	72,700	55,200	74,000	58,200	77,700	58,200
		Average	72,300	54,900	75,900	58,600	77,800	58,800
AM-C57S-H	.064	1	70,800	55,500	74,200	58,700	77,300	58,600
		2	69,700	54,000	73,700	57,500	74,900	64,200
		3	67,700	59,200	69,900	58,000	70,900	63,200
		Average	69,400	56,200	72,600	57,800	74,400	62,000
AM-3S-R	0.125	1	52,100	42,000	67,500	41,700	68,000	42,500
AM-52S-R	.125	1	55,200	40,000	69,600	38,700	71,600	41,800
		2	55,500	39,600	69,800	40,000	67,800	41,600
		3	55,500	43,000	69,700	40,000	71,300	40,700
		Average	55,400	40,900	69,700	39,600	70,200	41,400
AM-C57S-R	.125	1	57,500	39,300	70,700	43,100	76,300	44,700
AM-3S-R	0.250	1	55,600	38,200	59,700	39,800	63,200	41,800
AM-52S-R	.250	1	55,200	37,500	65,700	33,600	65,600	37,700
AM-C57S-R	.250	1	55,200	38,400	68,000	40,000	71,600	41,200

[a]Stress corresponding to offset of 2 percent of hole diameter from initial straight-line portion of curves in figs. 2 to 13 (0.005-in. offset for 1/4-in. pin; 0.010-in. offset for 1/2-in. pin).

TABLE IV.- RATIOS OF BEARING ULTIMATE AND YIELD STRENGTHS TO TENSILE STRENGTH FOR MAGNESIUM-ALLOY SHEET

Alloy and temper	Nominal thickness (in.)	Edge distance = 1.5D			Edge distance = 2D			Edge distance = 4D		
		Bearing ultimate strength / Tensile strength		Bearing yield strength[a] / Tensile strength	Bearing ultimate strength / Tensile strength		Bearing yield strength[a] / Tensile strength	Bearing ultimate strength / Tensile strength		Bearing yield strength[a] / Tensile strength
		1/2-in. pin	1/4-in. pin		1/2-in. pin	1/4-in. pin		1/2-in. pin	1/4-in. pin	
AM-3S-O	0.064	1.24	1.38	0.80	1.38	1.64	0.86	1.34	1.72	0.94
AM-52S-O	.064	1.36	1.48	.90	1.45	1.78	.95	1.44	1.83	1.09
AM-C57S-O	.064	1.34	1.33	.94	1.27	1.66	.92	1.32	1.67	1.06
AM-3S-H	0.064	1.36	1.51	1.06	1.39	1.62	1.07	1.34	1.63	1.10
AM-52S-H	.064	1.36	1.56	1.19	1.38	1.64	1.27	1.31	1.68	1.27
AM-C57S-h	.064	1.40	1.52	1.23	1.41	1.60	1.27	1.37	1.63	1.36
AM-3S-R	0.125	1.47	1.37	1.10	1.70	1.77	1.09	1.54	1.78	1.11
AM-52S-R	.125	1.36	1.40	1.04	1.63	1.76	1.00	1.64	1.78	1.05
AM-C57S-R	.125	1.31	1.38	.94	1.58	1.69	1.03	1.64	1.83	1.07
AM-3S-R	0.250	1.57	--------	1.07	1.76	--------	1.12	1.79	--------	1.17
AM-52S-R	.250	1.37	--------	.96	1.66	--------	.86	1.68	--------	.96
AM-C57S-R	.250	1.31	--------	.92	1.55	--------	.96	1.71	--------	.99

[a]Yield strengths determined from tests with 1/4-in. pin for 0.064-in. and 0.125-in. sheet; with 1/2-in. pin for 0.250-in. sheet.

APPENDIX A

Under some conditions AM-C57S-H and AM-C57S-O sheet are susceptible to stress-corrosion cracking. If the sheet is exposed to a corrosive medium under conditions in which the exposed surfaces are subjected to steady tensile stresses greater than about one-quarter of the yield strength, fracture of the material may occur in a time short enough to render the part structurally unsatisfactory. Protection of the sheet by painting will prolong its life but will not entirely prevent cracking where conditions are severe.

High steady residual tensile stresses left by welding, severe cold-forming operations, or faulty assembly of misalined parts appear to be the most serious in producing stress-corrosion cracking. The lower stresses produced by normal service loads, particularly by intermittent service loadings, do not appear to have any appreciable influence on the occurrence of stress-corrosion cracking, especially where the corrosive conditions are not severe. Therefore, alloy AM-C57S will probably be entirely satisfactory for applications where "locked-up" stresses are not present or are held to a value less than about one-quarter of the yield strength. Experience has shown that this alloy has been satisfactory in many applications.

Although the susceptibility to stress-corrosion cracking is present in AM52S and AM-C52S sheet, these alloys are definitely less susceptible than AM-C57S sheet. No tendency toward stress-corrosion cracking has been found in AM3S alloy.

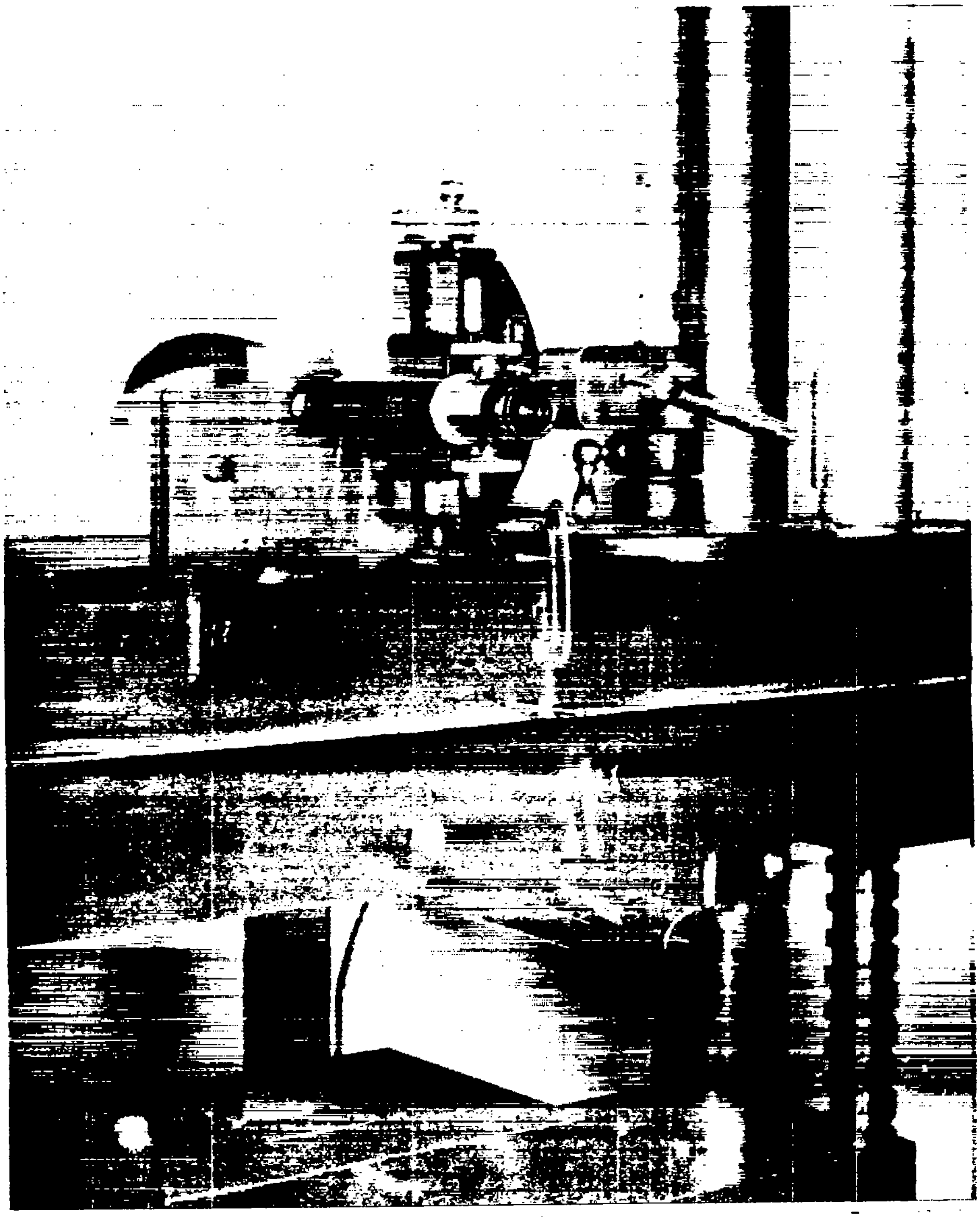
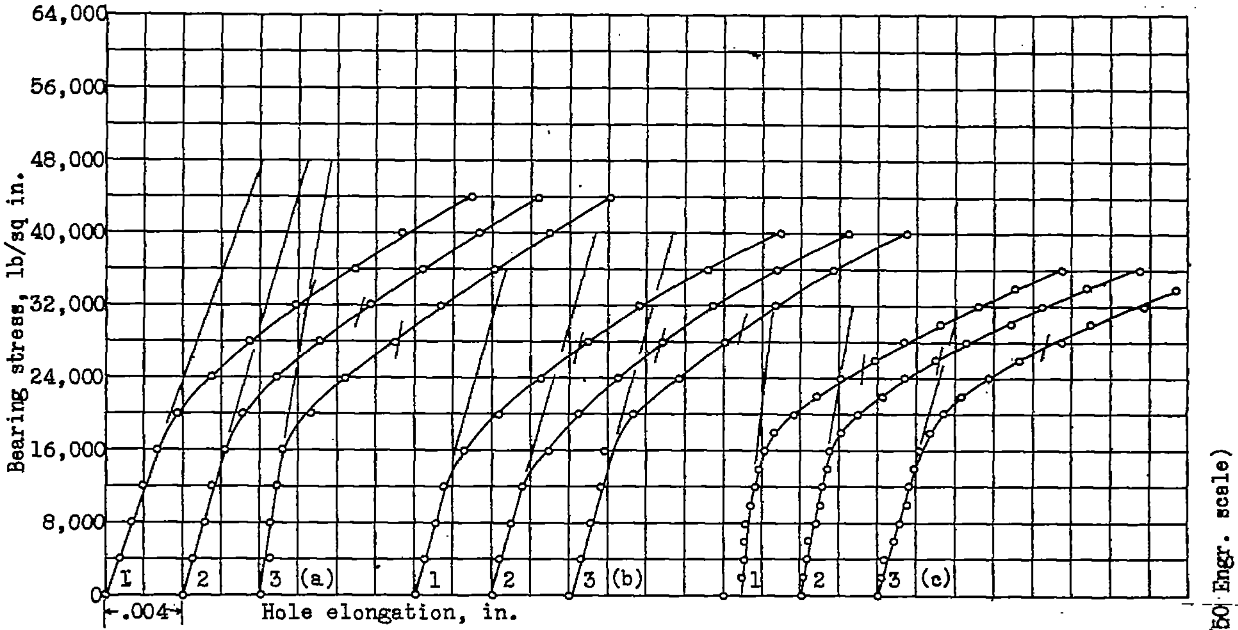
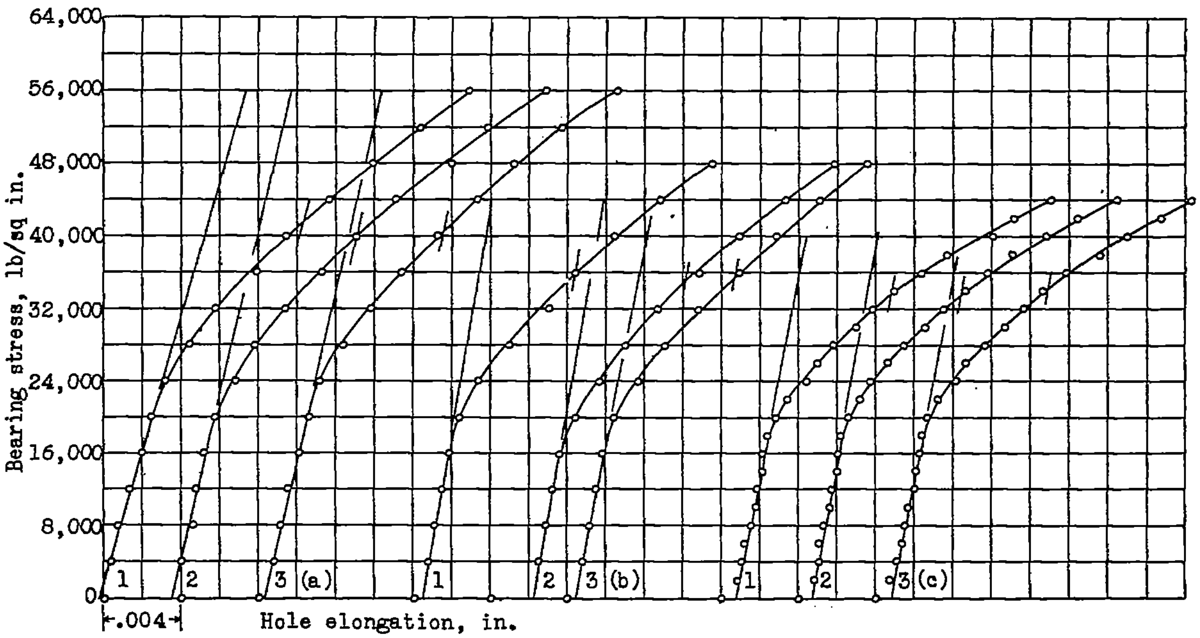


Figure 1.- Arrangement for bearing tests with filar micrometer microscope for measurement of hole elongation.
The specimen was illuminated from both sides, but the front light is not shown.



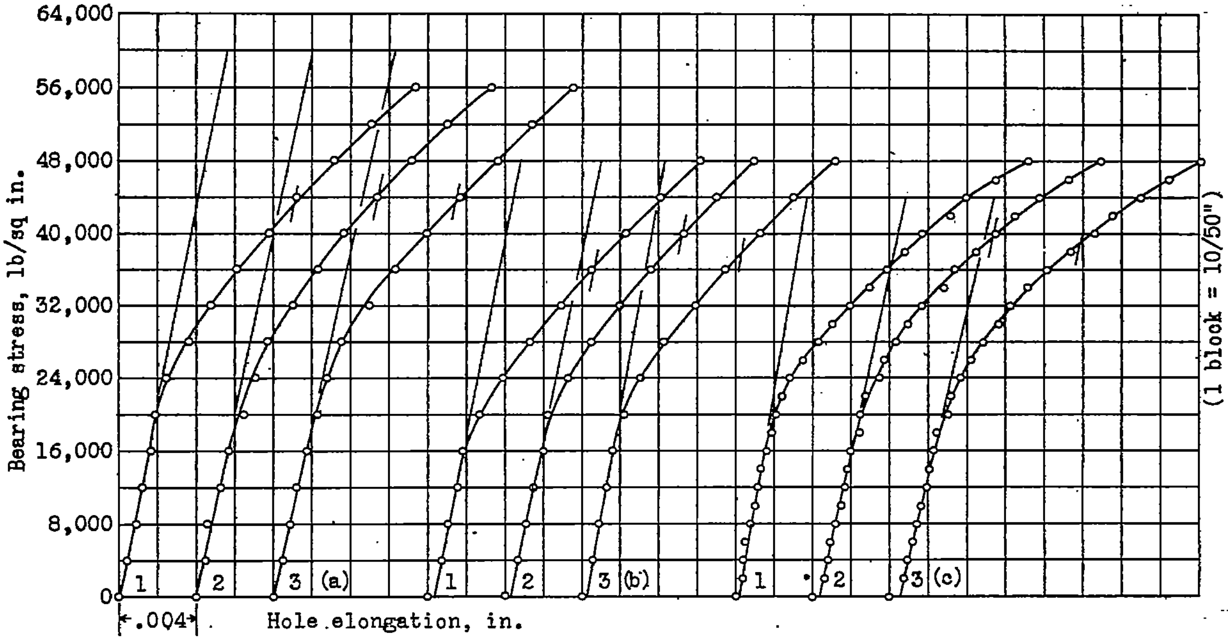
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 2.- Bearing stress against hole elongation for AM-3S-0 magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.



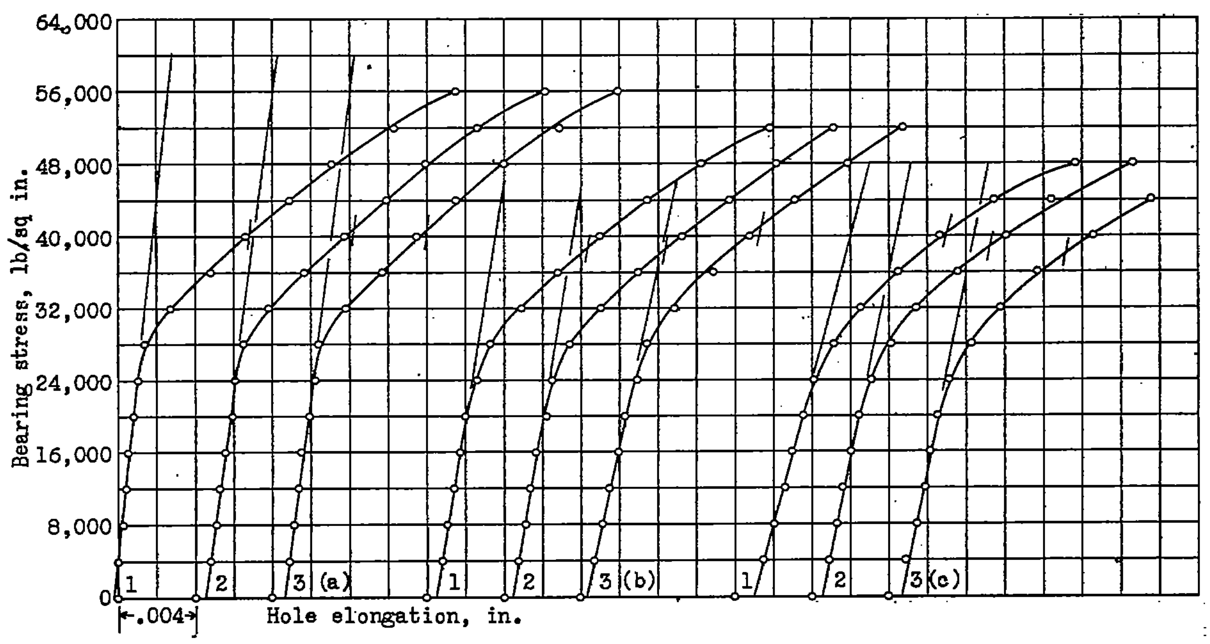
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 3.- Bearing stress against hole elongation for AM-52S-0 magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.



(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 4.- Bearing stress against hole elongation for AM-C57S-O magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.



(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 5.- Bearing stress against hole elongation for AM-3S-H magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.

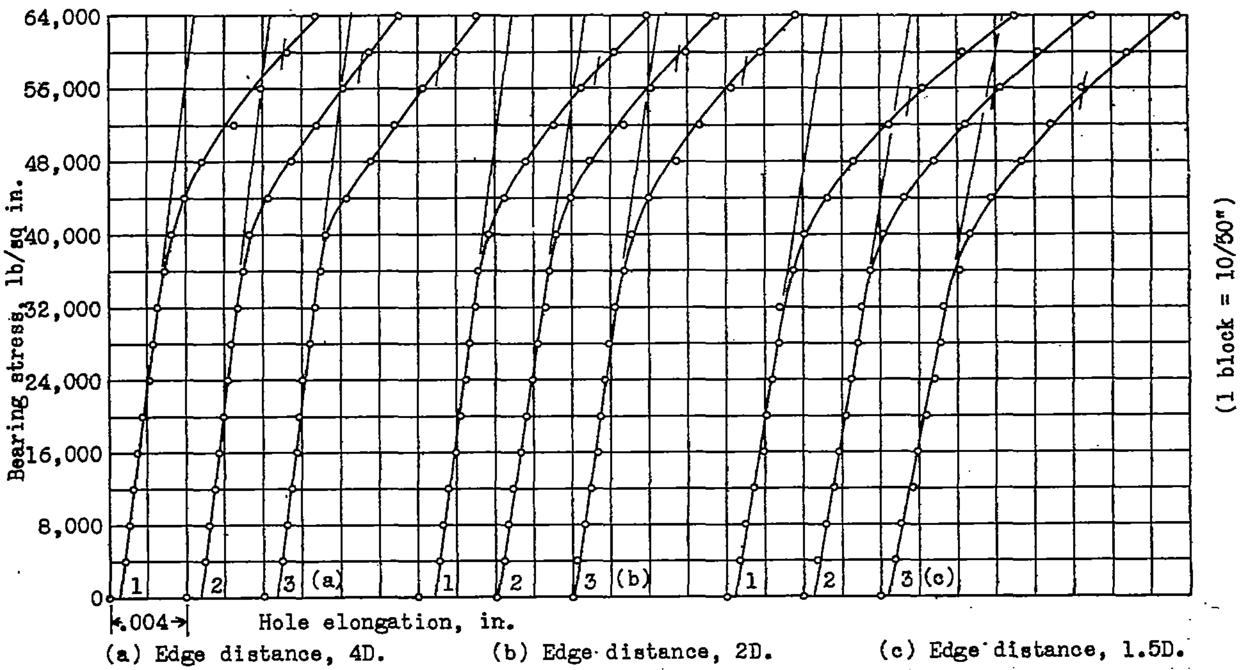


Figure 6.- Bearing stress against hole elongation for AM-52S-H magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.

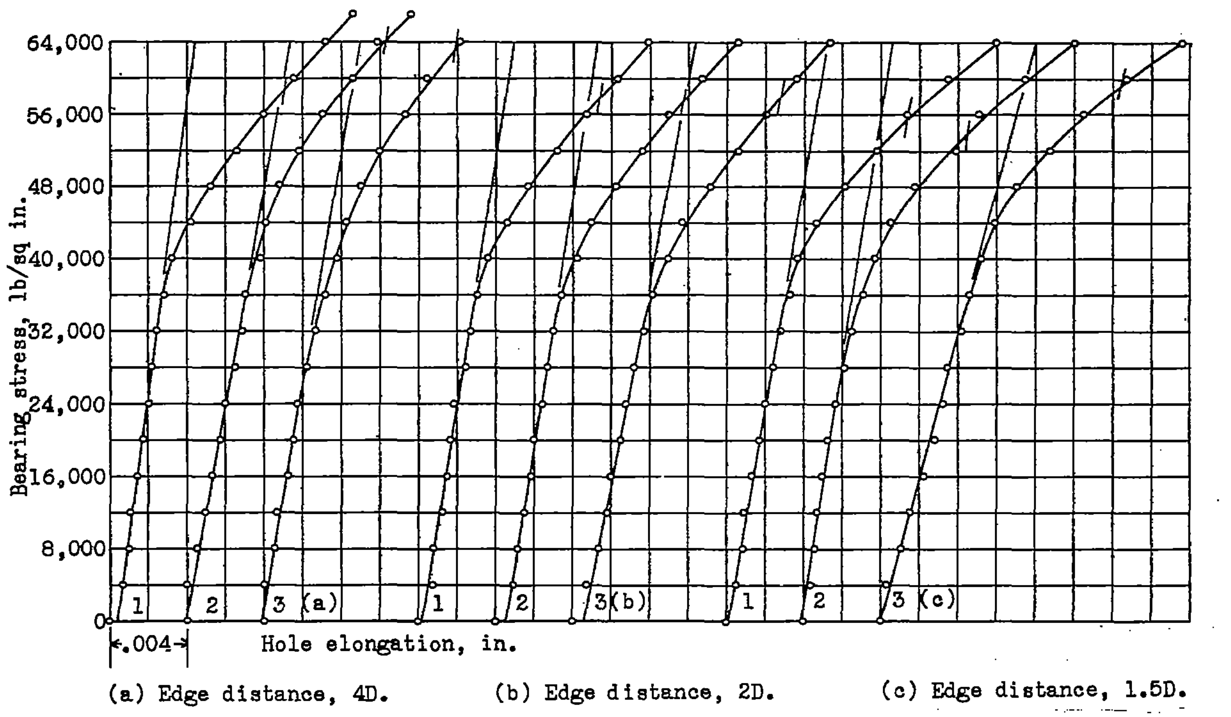
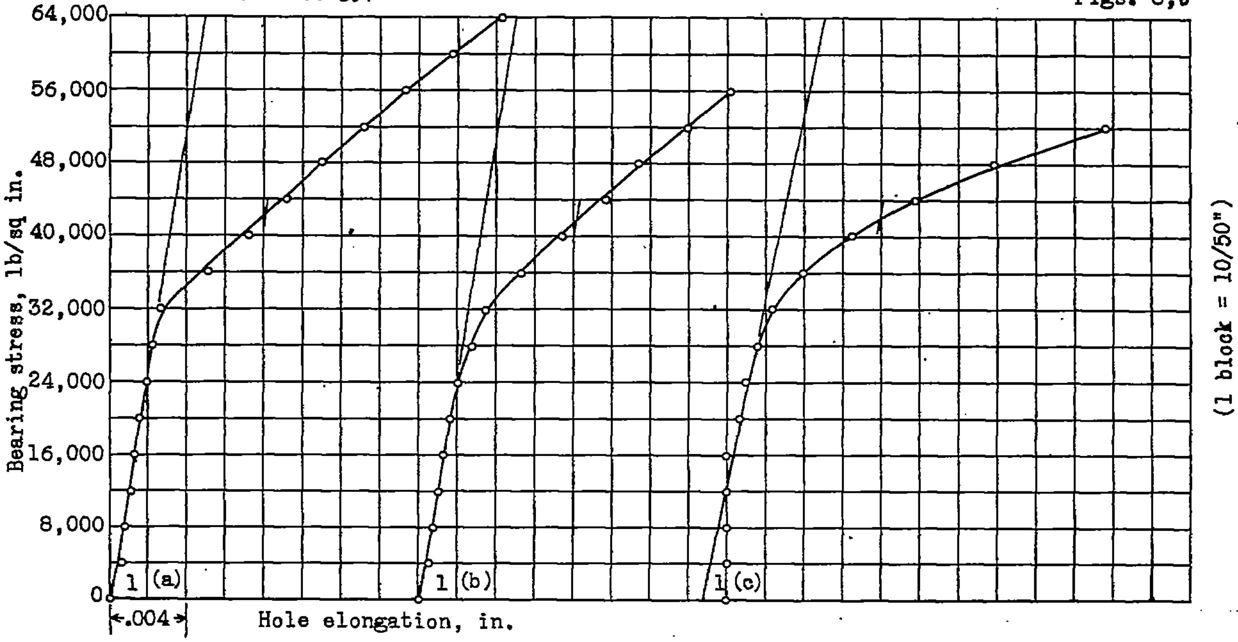
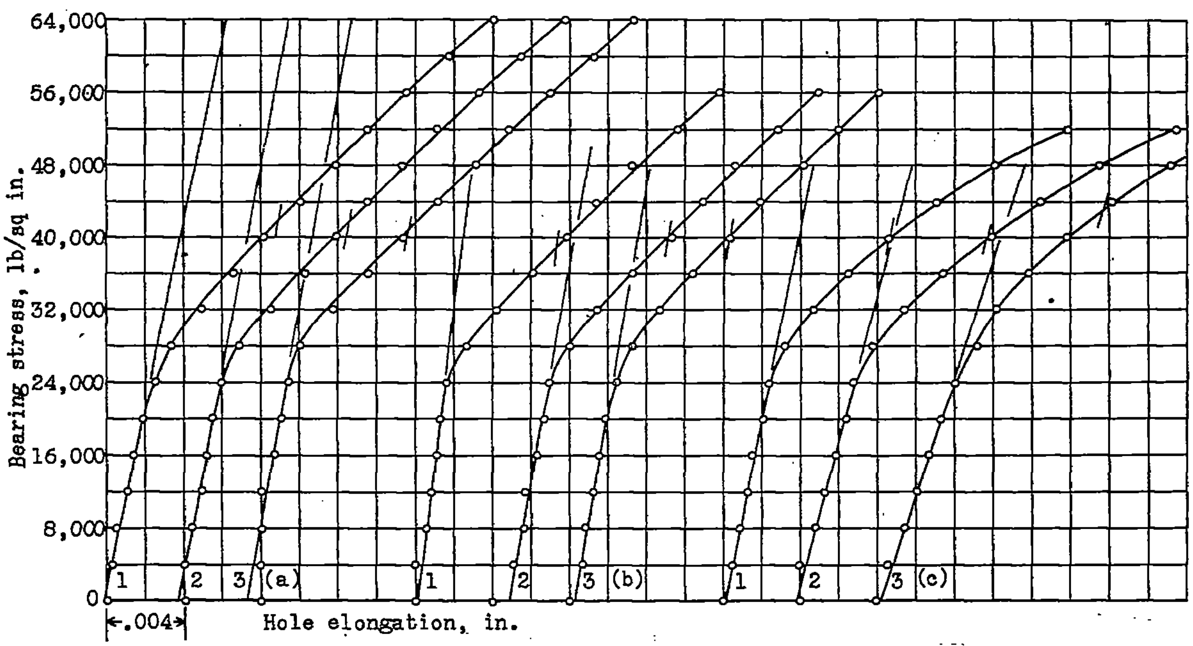


Figure 7.- Bearing stress against hole elongation for AM-C57S-H magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.064 inch; specimen width, 2 inches.



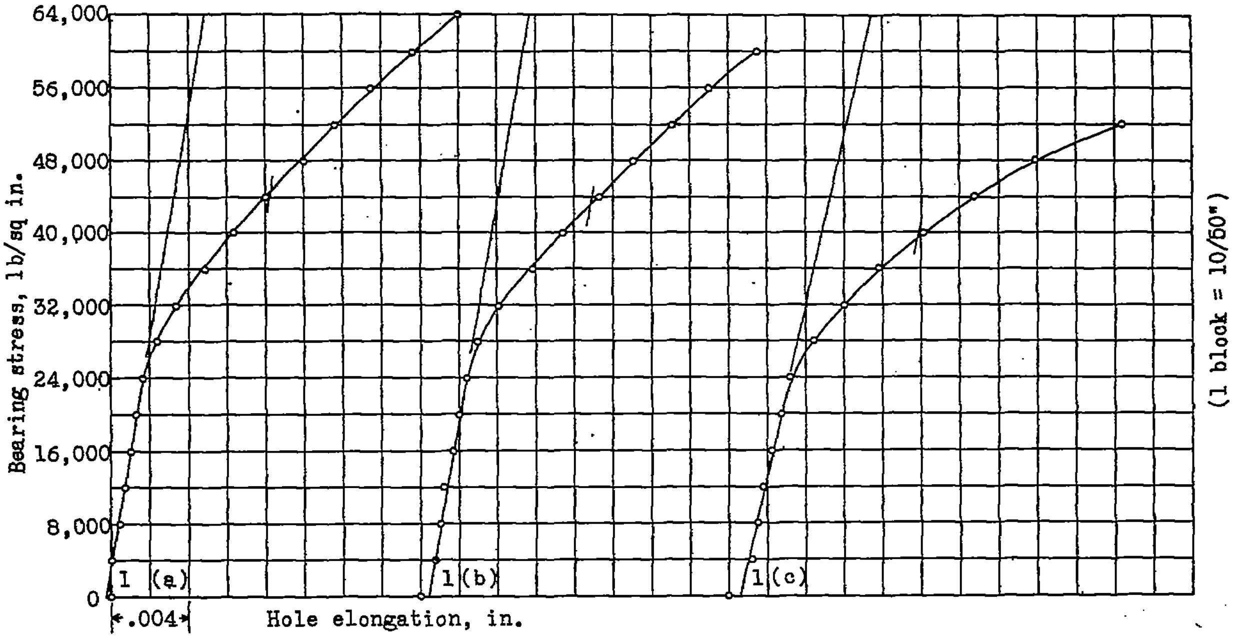
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 8.- Bearing stress against hole elongation for AM-3S-R magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.125 inch; specimen width, 2 inches.



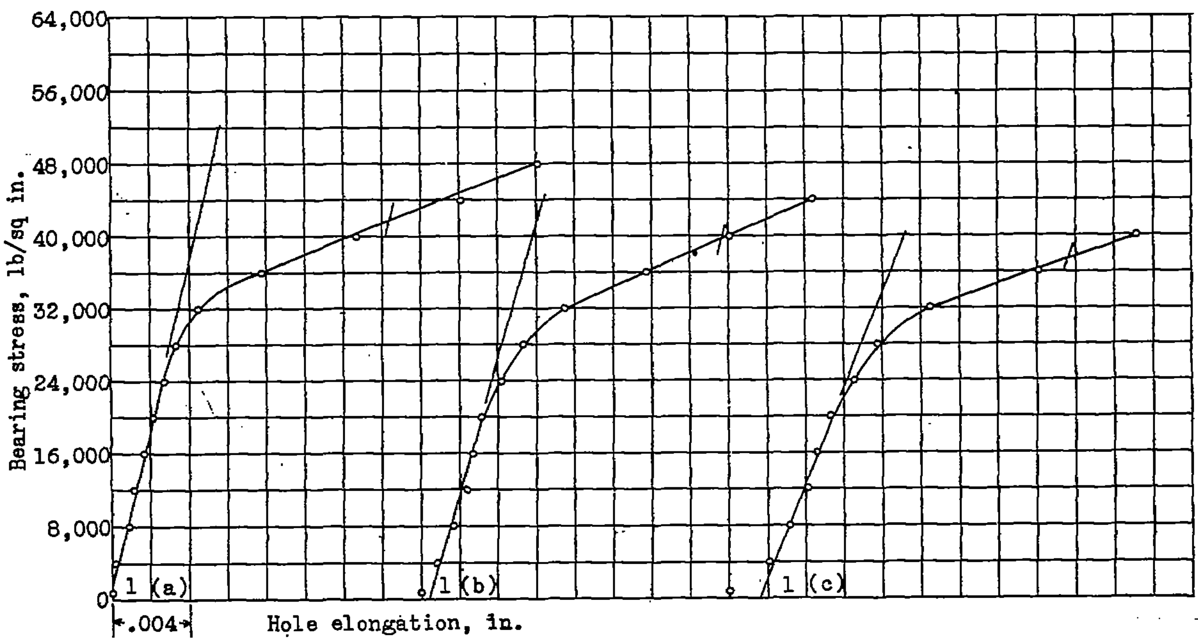
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 9.- Bearing stress against hole elongation for AM-52S-R magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.125 inch; specimen width, 2 inches.



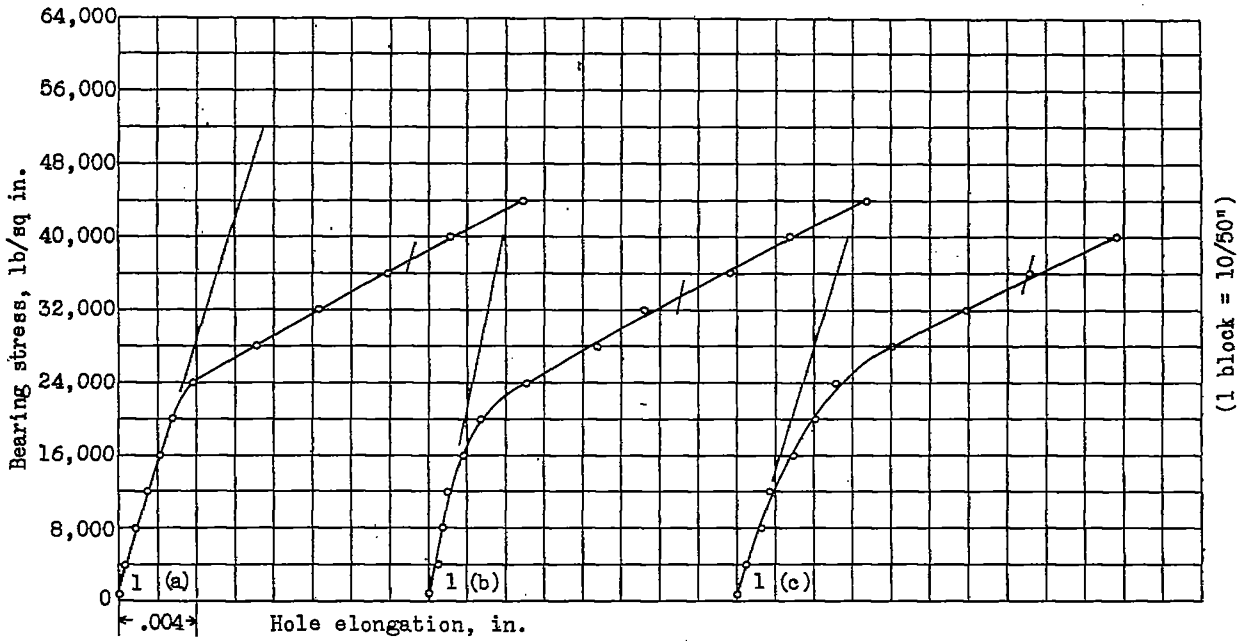
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 10.- Bearing stress against hole elongation for AM-C57S-R magnesium-alloy sheet. Pin diameter, 1/4 inch; sheet thickness, 0.125 inch; specimen width, 2 inches.



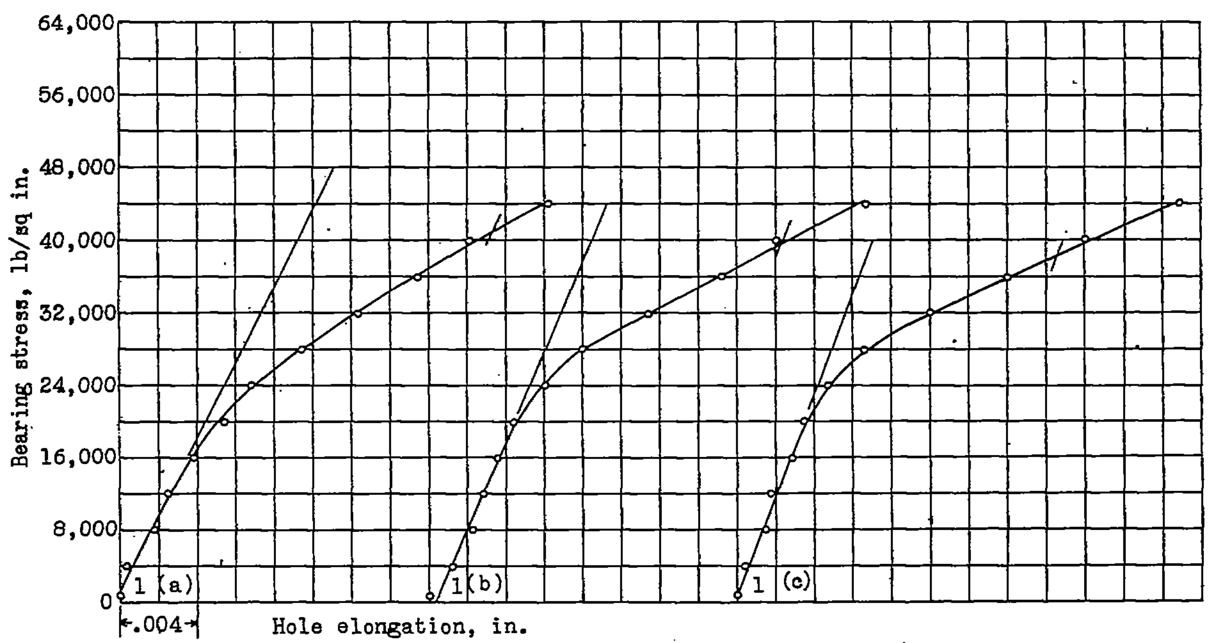
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 11.- Bearing stress against hole elongation for AM-3S-R magnesium-alloy sheet. Pin diameter, 1/2 inch; sheet thickness, 0.250 inch; specimen width, 2-1/4 inches.



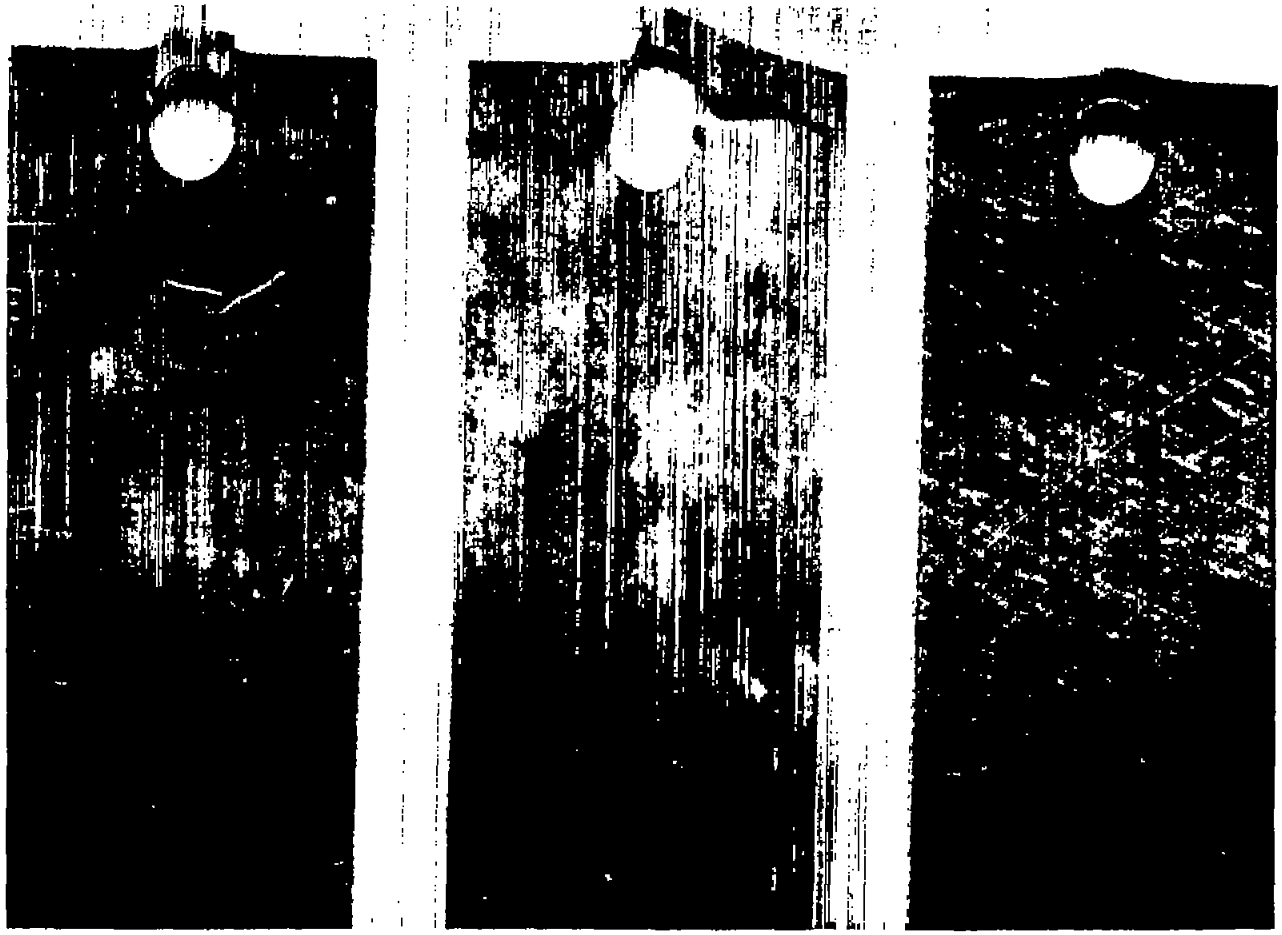
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 12.- Bearing stress against hole elongation for AM-52S-R magnesium-alloy sheet. Pin diameter, 1/2 inch; sheet thickness, 0.250 inch; specimen width, 2-1/4 inches.



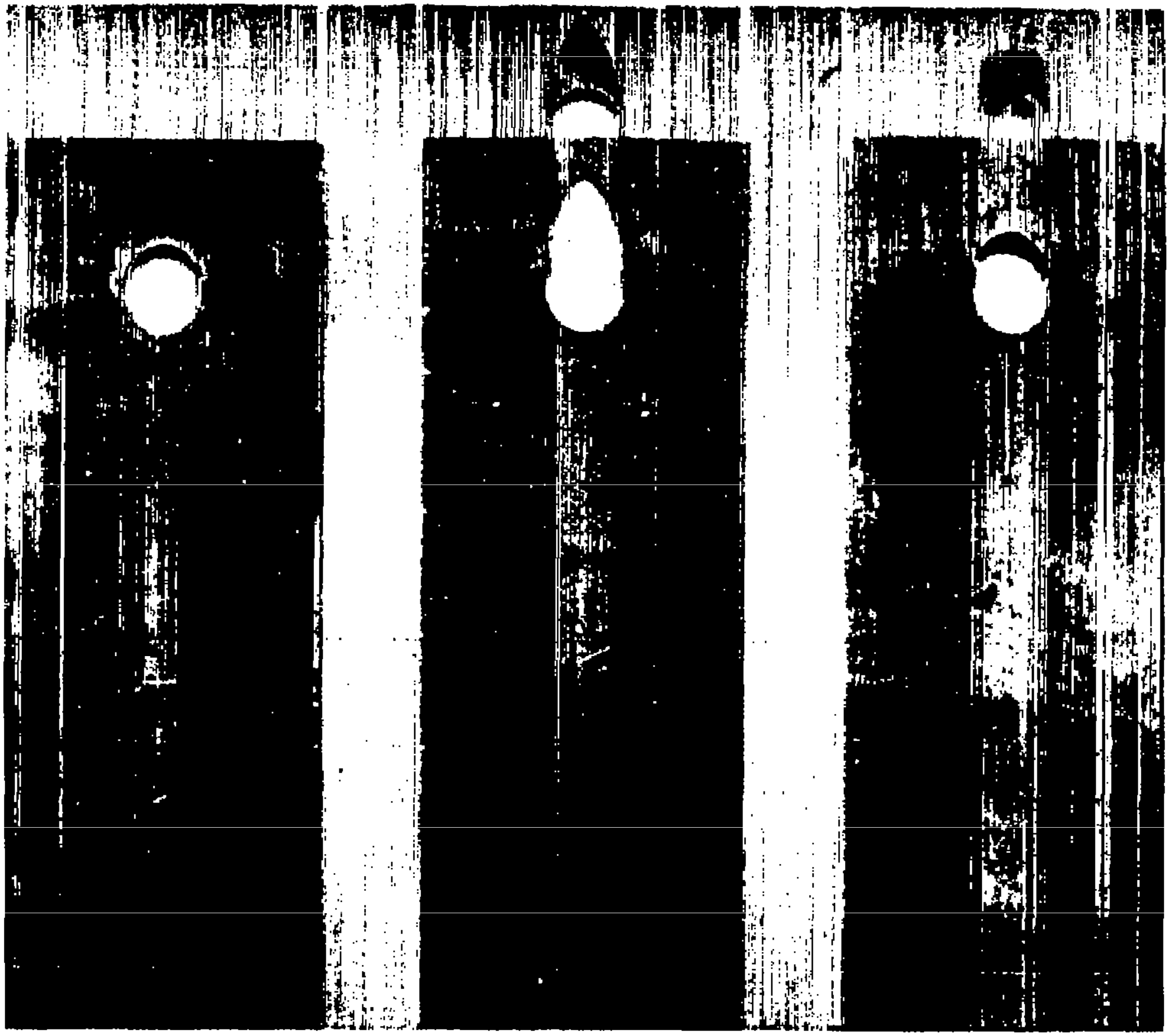
(a) Edge distance, 4D. (b) Edge distance, 2D. (c) Edge distance, 1.5D.

Figure 13.- Bearing stress against hole elongation for AM-C57S-R magnesium-alloy sheet. Pin diameter, 1/2 inch; sheet thickness, 0.250 inch; specimen width, 2-1/4 inches.



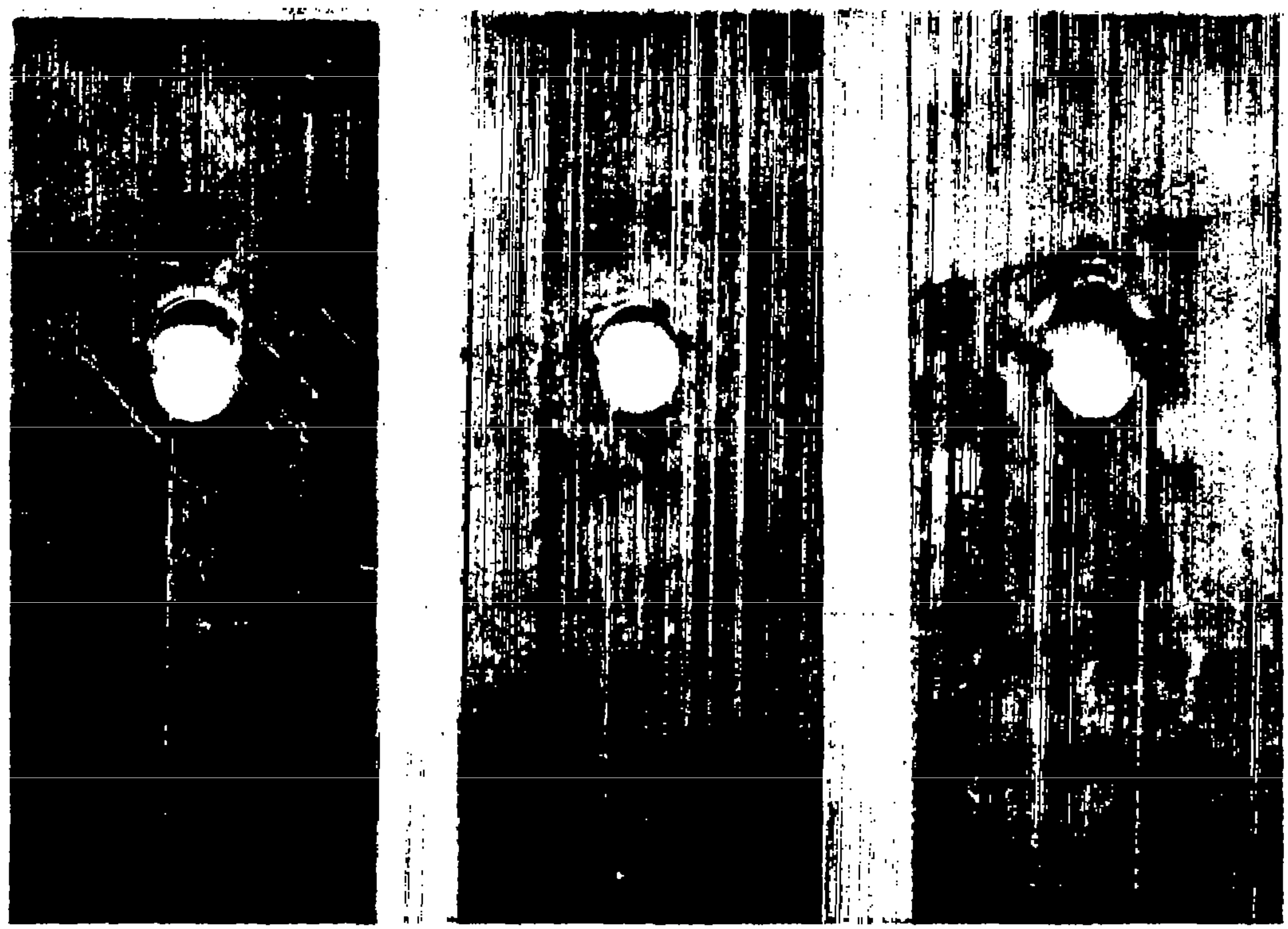
t = 0.064 in. t = 0.125 in. t = 0.250 in.

Figure 14.- Typical failures for edge distance of 1D.



t = 0.064 in. t = 0.125 in. t = 0.250 in.

Figure 15.- Typical failures for edge distance of 2D.



t = 0.064 in. t = 0.125 in. t = 0.250 in.

Figure 16.- Typical failures for edge distance of 4D.